JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 14 NOVEMBER 19, 1924 No. 19

GEOPHYSICS.—*The radial distribution of certain elements in the Earth.*[1] HENRY S. WASHINGTON. Geophysical Laboratory, Carnegie Institution of Washington.

According to the generally accepted geophysical theory the Earth is constituted—speaking broadly—of a central core of nickel-iron, surrounded by a thick shell of stony matter, the thin, outermost, solid, and crystalline skin of which is called the "crust." This general concept of the distribution of matter in the Earth is more or less varied in detail, according to individual views as to the data to be considered as fundamental and the different interpretations of them.[2]

In recent papers[3] a fairly detailed distribution of matter, both in composition and in depth, has been suggested, which is based on what is known of the relations of the velocity of earthquake waves to depth, the distribution of density, the compressibility of minerals and rocks,[4] the petrology of igneous rocks, and, especially, on analogy with meteorites. This distribution, which is in general accord with that suggested by several others (Suess, Wiechert, Gutenberg, and Clarke), is characterized by a striking distribution of certain elements,

[1] Received October 20, 1924.

[2] For an exposition of what is known as to the interior of the Earth and a resumé of the various theories as to the distribution of matter within it, see a forthcoming paper, *The interior of the Earth and its relation to the crust*, to be published in Journ. Franklin Inst. 1925.

[3] WILLIAMSON and ADAMS. *Density distribution in the Earth.* This JOURNAL **13**: 413. 1923; F. W. CLARKE. *The evolution and disintegration of matter.* U. S. Geol. Survey, Prof. Paper 132-D, 76. 1924; ADAMS and WASHINGTON. *The distribution of iron in meteorites and in the Earth.* This JOURNAL **14**: 333. 1924; ADAMS and WILLIAMSON. *The composition of the Earth's interior.* Smithsonian Inst., Ann. Rep. 1923: (in press).

[4] ADAMS and WILLIAMSON. *The compressibility of minerals and rocks at high pressures.* Journ. Franklin Inst. **195**: 475. 1923.

notably oxygen and silicon, from the center to the surface, to which it is the purpose of this note to call attention. Such details as the depth and the thickness, and the physical characters, of the several shells, will not be considered here.

The central "core," composed of nickel-iron, as are the sideritic meteorites, contains neither oxygen nor silicon; on the contrary, non-oxide compounds—phosphides, carbides, and sulphides—are probably present in considerable amount. Compounds of aluminum, calcium, sodium, and potassium are also wholly lacking.

Near the border of the iron core silicon and oxygen, as silicate, enter into the composition, the amount gradually increasing outward, so as to form a spherical shell or "sphere" of mixed nickel-iron and silicate, in which the silicate is sporadic, that is to say, scattered as discrete particles in a continuum of iron, the texture being in general like that of meteoritic pallasite.[5] The silicate in this shell, from analogy with meteorites, is mostly olivine, an orthosilicate of iron and magnesium, 2 (Fe, Mg)O. SiO_2; with none, or subordinate amounts, of the metasilicate pyroxene, (Fe, Mg)O.SiO_2. In this "lithosporic" shell the silicate and metal are present on the average, or near the middle of the shell, in approximately equal amounts, the metal content gradually diminishing outwardly.

This "lithosporic" shell, in turn, passes gradually into a "ferrosporic" shell, one in which the nickel-iron is sporadic in a continuum of silicate, the silicate being a mixture of olivine and pyroxene. The metallic content is here greatly diminished, being, on the average probably not over about 15 per cent. Some non-oxide compounds, phosphides and sulphides, are probably also present in small amount in both these shells. Through a gradual diminution in the amount of nickel-iron this shell merges into an outer shell composed almost wholly of silicates, these being mostly pyroxene and olivine, in which (again from analogy with meteorites), the amount of pyroxene is greater than that of olivine. This material corresponds to the achondritic meteorites. There may be present also a little anorthite, orthosilicate of aluminum and calcium. The non-silicates present are mostly oxides, especially magnetite and chromite, probably with sulphides, borides, and nitrides.

Above this shell lies the "crust," probably about 60 kilometers thick—certainly not over about 100 kilometers, as is indicated by

[5] Cf. ADAMS and WASHINGTON. *The distribution of iron in meteorites and in the Earth.* This JOURNAL **14**: 333. 1924. The terms "lithosoporic" and "ferrosporic" are here proposed and defined.

several convergent lines of evidence, thermal, seismic, isostatic, petrologic, etc. The material of the lower part of the "crust" is supposed to be in general gabbroic or basaltic, that is to say, a mixture of pyroxene and soda-lime feldspar, which may be typified as labradorite, a mixture of orthosilicate anorthite ($CaO \cdot Al_2O_3 \cdot 2SiO_2$), and polysilicate albite ($Na_2O \cdot Al_2O_3 \cdot 6SiO_2$), in about equal parts. Probably a little olivine is present, and there is a little magnetite (Fe_3O_4). In the lower part of the crust, therefore, aluminum and calcium, which have been almost negligible below, become abundant, and sodium, which was scarcely present below, here becomes a prominent constituent. In the lower part of the "crust" there is almost certainly no, or only a negligible amount of, potassium and excess silica. Potassium and excess silica begin to come in toward the upper part of the "crust," in the forms of polysilicate orthoclase ($K_2O \cdot Al_2O_3 \cdot 6SiO_2$), and quartz ($SiO_2$), until near the surface they are the most abundant minerals, along with dominantly sodic plagioclase, andesine, and oligoclase. In this upper part, which may be approximately 15 to 20 kilometers thick, the material is overwhelmingly granitic or granodioritic in the continental masses, the material of the ocean floors being essentially basaltic.[6] In this outermost, granitic shell, furthermore, the relative amount of iron-magnesium silicate has greatly diminished, and is mostly biotite and hornblende, with augite and other pyroxenes, the general excess of silica precluding the presence of orthosilicate olivine in notable amount, except more or less locally, as in flows of olivine basalt and such rocks.

Finally, oxygen is abundant in the hydrosphere and is free in the lower part of the all-enveloping atmosphere.

Several independent, convergent, and mutually corroborative lines of evidence indicate that the above described distribution of matter in the Earth is approximately correct or, at least, very probably true in its broad lines. The details of the evidence cannot be discussed here; they will be found set forth at length in the forthcoming paper referred to above. Granted that such is the true, or approximately true, state of affairs within the Earth, it follows that there is a progressive increase in the relative amount of certain elements and an inverse progressive decrease in the relative amount of others, from the center to the surface of the Earth.

[6] For the average composition of the continental masses, the ocean floors, and smaller areas, see CLARKE and WASHINGTON. *The average chemical composition of igneous rocks.* Proc. Nat. Acad. Sci. **8**: 108–115. 1922; WASHINGTON. *Isostasy and rock density.* Bull. Geol. Soc. America **33**: 388. 1922; CLARKE and WASHINGTON. *The composition of the Earth's crust.* U. S. Geol. Survey, Prof. Paper 127, 13–15, 42–69. 1924.

Speaking generally, not only does the relative amount of silicates increase from the center outward, but the degree of silication increases in the same sense. Near the central, metallic core these compounds are all or mostly orthosilicate, then come mixtures of orthosilicate and metasilicate, then mostly metasilicate, all of these silicates of iron and magnesium, with probably some calcium-aluminum orthosilicate (anorthite) toward the top. Then sodic polysilicate enters, balancing the calcic orthosilicate so far as the relative silica content is concerned; next polysilicates are dominant; and finally there is abundant excess or free silica with alkali polysilicates, both together largely dominant over gradually diminishing metasilicate, and with ortho-

TABLE 1.—THE PERCENTAGES OF SILICA, SILICON, AND OXYGEN IN MINERALS

MINERAL	SILICA	SILICON	OXYGEN
Fe_2SiO_4	29.4	13.7	31.4
$Fe_2SiO_4 + Mg_2SiO_4$ (1:1)	**36.2**	**16.9**	**38.6**
Mg_2SiO_4	42.9	20.0	45.7
$(Fe, Mg)_2SiO_4 + (Fe,Mg)SiO_3$ (1:1)	**44.2**	**20.8**	**49.4**
$FeSiO_3$	45.5	21.2	36.4
$FeSiO_3 + MgSiO_3$ (1:1)	**52.8**	**24.6**	**42.2**
$MgSiO_3$	60.0	28.0	48.0
$CaAl_2Si_2O_8$	43.2	20.1	46.4
$(Fe,Mg)SiO_3 + CaAl_2Si_2O_8$ (1:1)	**48.0**	**22.4**	**44.3**
$CaAl_2Si_2O_8 + NaAlSi_3O_8$ (1:1)	**55.9**	**26.1**	**47.6**
$CaAl_2Si_2O_8 + NaAlSi_3O_8$ (1:3)	**62.3**	**29.1**	**48.2**
$NaAlSi_3O_8$	68.7	32.1	48.8
$KAlSi_3O_8$	64.7	30.2	46.4
$KAlSi_3O_8 + SiO_2$ (1:1)	**73.5**	**34.3**	**47.8**
SiO_2	100.0	46.7	53.3

silicate practically absent. Inverse to this progressive increase in silica is the progressive diminution in nickel-iron, in silicates of iron and magnesium, and probably also in non-oxide compounds.

As a consequence of the progressive increase in silica, there is also progressive increase in the relative amounts of silicon and oxygen from the center outward. The progression of the three constituents, silica, silicon, and oxygen, is to be seen in the accompanying tables 1 and 2, in which are given their percentages in, respectively, the principal minerals and some ideal mixtures of them, and in the assumedly average successive shells, from the center to the surface (reading downward). Because of the great difference in the atomic weight of iron and magnesium, and consequently in the molecular weight of their homologous silicates and in the percentage of silica

in these, the progression is best seen if mixtures[7] of the ortho- or metasilicates of the two elements (for convenience in equal amount) are compared with each other and with the feldspars.

More detailed consideration of the general distribution shows that, superposed on the two inverse progressions (of silicates and of nickel-iron) are progressions in the basic elements of the silicates. Iron and magnesium (as silicates) increase at first from the border of the nickel-iron core until they reach a maximum in the metal-free (achondritic) shell, composed essentially of olivine and pyroxene. Above this they steadily decrease until they are almost (or quite) negligible in the granitic upper part of the "crust," represented by the continental

TABLE 2.—THE PERCENTAGES OF SILICA, SILICON, AND OXYGEN IN THE EARTH SHELLS

SHELL	SILICA	SILICON	OXYGEN
Nickel-iron core	0.0	0.0	0.0
Lithosporic shell[1]	18.1	8.5	19.3
Ferrosporic shell[2]	35.4	16.6	32.3
Metal-free shell[3]	44.2	20.8	40.4
Lower part of "crust"[4]	48.0	22.4	44.3
Upper part of "crust"[5]	59.1	27.7	46.6

[1] Olivine:nickel-iron = 1:1.
[2] Pyroxene + olivine:nickel-iron = 4:1.
[3] Pyroxene:olivine = 1:1.
[4] Pyroxene:anorthite = 1:1.
[5] According to Clarke and Washington.

masses. It is unknown whether there is any concomitant progressive change in the ratios between the two: it would seem to be probable that there is such a variation, but time is lacking at present for proper study of this phase of the subject.

The evident progression in the relative amounts of calcium, sodium, and potassium, is also of interest. Calcium begins to appear in the upper part of the ferrosporic pyroxene-olivine shell, accompanied by very small amounts of sodium, and without any potassium. The relative amount of calcium reaches a maximum in the lower, basaltic part of the "crust," where it forms part of both pyroxene and feldspar. Here sodium begins to assume important proportions, its amount increasing gradually upward, while the amount of calcium decreases almost inversely. Finally, with the appearance of potassium, probably about the middle of the crustal shell, the amount of calcium be-

[7] Mixtures are indicated by bold-faced type.

comes very small. From this point upward the alkali metals largely dominate over calcium, potassium at the same time gradually increasing over sodium, and excess silica becoming abundant.

The upward progression of aluminum is determined largely by the fact that in the chief minerals of which it is a constituent (anorthite, albite, orthoclase) it is present in equal molecular amount with the bases calcium, sodium, and potassium, except for the small amount present in augite (probably in solid solution), in hornblende, and as an essential part of the molecule in biotite and muscovite. These minerals (augite, hornblende, and micas), however, appear to be formed only under the conditions that control in the upper part of the "crust."

The elements that have been considered in this discussion of progressions are all, with the exception of nickel, those that are most abundant in the "crust" of the Earth, of which they together make up 98.6 per cent.[8] These elements and their percentages, in the order of abundance, are: oxygen 46.59, silicon 27.72, aluminum 8.13, iron 5.01, calcium, 3.63, sodium 2.85, potassium 2.60, magnesium 2.09. The amount of iron has decreased from about 91 per cent to 5 per cent; while the amount of nickel, which in the central core amounts to probably about 8.5 per cent,[9] has diminished at the surface to 0.02 per cent.[8] Similarly, the amount of magnesium has dropped from its maximum of about 13 per cent in the pallasitic shell to 2 per cent in the crust. The effects of the several progressions are thus clearly evident.

A noteworthy feature of the progressions outlined above is that they follow in the order of what has been called the "affinity for silica" of the most abundant oxides (except alumina).[10] This order is: $K_2O > Na_2O > CaO > MgO > FeO$. Thus, one molecule of potash and soda can bind up to six molecules of silica, one of lime up to two of silica, one of magnesia up to one of silica and one of ferrous oxide up to one of silica and ferrous oxide, can exist in rocks (as magnetite $FeO.Fe_2O_3$) uncombined with free silica.

Also, this order is the order of oxidizability of the metals concerned. The very ready oxidizability of the alkali metals is well known,

[8] CLARKE and WASHINGTON. *The composition of the Earth's crust.* U. S. Geol. Survey, Prof. Paper 127, 20. 1924.

[9] Cf. FARRINGTON. *Analyses of stone meteorites.* Field Mus. Publ. **151**: 212. 1911.

[10] Cf. WASHINGTON. *The chemistry of the Earth's crust.* Journ. Franklin Inst. **190**: 791. 1920; CLARKE and WASHINGTON. *The composition of the Earth's crust.* U. S. Geol. Survey, Prof. Paper 127, 100. 1924.

potassium being somewhat more easily oxidizable than sodium; calcium is fairly stable in the air, but oxidizes slowly; magnesium is much more stable in the air than is calcium, but a wire or ribbon of it burns readily; iron is quite stable in the air, much more so than magnesium—a thin wire or ribbon of it cannot readily be burned.

In other words, the order of characteristic occurrence of the elements from the surface to the center is that of the positions of the respective metals of the electrochemical series, namely: K, Na, Ca, Mg, (Al), Fe, Ni. Tammann[11] has also expressed the idea that the elements in the Earth are arranged generally, from the surface to the center in the order of their electro-affinity, from the most electropositive to the most electronegative, those that are more electropositive than iron forming the crust.

Such a general distribution as has been suggested above has been often compared to the slag and metal in iron smelting, or the metal, matte, and slag in the smelting of copper. Indeed, Goldschmidt[12] and Tammann[13] carry this latter comparison to the extent of suggesting the presence of a shell of sulphides between the crust and the central, metallic core.

It would thus appear that the Earth, as a whole, is mainly composed, to the extent of over 98 per cent, of only seven elements. These seven, in their order of abundance, are: iron, oxygen, silicon, magnesium, nickel, calcium, and aluminum. Smaller amounts of four others, sulphur, sodium, chromium and potassium, bring the percentage to 99.60. Most of the other 81 elements may, therefore, be regarded as "impurities," possibly produced, as Clarke has suggested, by some process of evolution. It is noteworthy, also, that the above elements, with hydrogen and cobalt, appear to be those most abundant in the Sun's atmosphere.[14]

It may be of interest to call attention to the resemblance in some respects between the progression of the chief elements in the Earth and that in the atmosphere of the Sun, as recently interpreted.[15] In the chart of the Sun's atmosphere given by St. John and Babcock ionized calcium lies highest up, followed below by a thick shell of

[11] G. TAMMANN. *Zur Analyse des Erdinnern.* Zeitschr. Anorg. Chem. **131**: 96. 1923.

[12] V. M. GOLDSCHMIDT. *Der Stoffwechsel der Erde.* Vid.-selsk. Skrifter 1922: no. 11; *Geochemische Verteilungsgesetze der Elemente.* Vid.-selsk. Skrifter. 1923: no. 3.

[13] G. TAMMANN. *Zur. Analyse des Erdinnern.* Zeitschr. Anorg. Chem. **131**: 96. 1923.

[14] Cf. C. G. ABOTT. *The Sun*, 91. 1911.

[15] ST. JOHN and BABCOCK, *Note on the pressure and currents in the Sun's atmosphere.* Proc. Nat. Acad. Sci. **10**: 390. 1924.

hydrogen; below this by titanium (ionized), sodium, and calcium; and at the bottom of the solar atmosphere a thin shell of iron vapor, with lanthanum.[16]

Some interesting questions suggest themselves in connection with the distribution of the chief elements in the Earth: What is the origin of the relatively enormous mass of metallic nickel-iron? Was there originally sufficient silica to silicatize all the nickel-iron? Is it due to reduction of original silicate, and if so by what reducing agent? Is "gravitative adjustment" alone responsible for the stratification or do other factors come in? Has there been an actual progressive oxidation or silication, such as is indicated by Prior's studies on meteorites? To what extent downward does the surficial areal heterogeneity (shown by the continental masses and the ocean floors) extend, and what is the cause of these heterogeneities? But attempts to give even speculative answers to these and other questions must await another occasion.

SPECTROSCOPY.—*Regularities in the arc spectrum of columbium.*[1] W. F. MEGGERS, Bureau of Standards.

Last year, a note was published[2] on *Regularities in the arc spectrum of vanadium.* These regularities were discovered by means of certain properties of spectral lines in multiplet structures, such as constant wave-number differences, temperature classification, and intensity rules accompanying transitions of azimuthal and inner quantum numbers. In a second note[3] some of these structures were confirmed by data on the Zeeman effect for vanadium lines, and some new multiplets were given. These and additional results not yet published indicate that most, if not all, of the spectrum lines of neutral vanadium may be explained by combinations of terms belonging to systems whose maximum multiplicities are even, i.e., doublets, quartets and sextets.

Similar studies have been made with the arc spectrum of columbium which occupies a position directly under vanadium in the periodic system of the chemical elements. This spectrum was expected to possess structures like those found for vanadium, and as far as the

[16] The "AL" in the first column of the chart is presumably a misprint for "LA", according to the text on page 391.

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

[2] MEGGERS. This JOURNAL **13**: 317. 1923.

[3] MEGGERS. This JOURNAL **14**: 152. 1924.

analysis has been completed, this has been confirmed. It has been impossible, however, to make the analysis for columbium as complete as that for vanadium, chiefly on account of the lack of accurate and complete data on its spectrum. The arc spectrum of columbium was partially described by Exner and Haschek[4] in a table of 1770 wave-lengths from 2376 A to 7047 A. Four hundred lines (4638–7047 A) have been measured on the international scale of wave lengths and published by Eder and Valenta.[5] The precision of the published values of wave-lengths and intensities is, in general, not as high as desirable for the purpose of recognizing polyfold levels from their various combinations. No data on the absorption spectrum, nor of its spectra in furnaces at various temperatures, exist for this element, although investigations to supply these have been recently undertaken by Dr. King at the Mt. Wilson Observatory. A very excellent study of the magnetic resolution of the spectrum lines of columbium was made by Jack[6] who determined the patterns for nearly 800 lines. Unfortunately only about 100 of these have been published, and the result is that even many of these are of little avail in the absence of other aids in completing multiplets. Furthermore, according to the general rule that in any particular column of the periodic table, the separations of the polyfold levels are larger for the heavier elements, these separations are, in the mean, three to four times larger for columbium than for vanadium. The result is that the multiplets for the former, being spread over larger intervals, are more likely to overlap, and are consequently more difficult to disentangle than those for the latter. These considerations have led me to publish only a few of the columbium multiplets at the present time, and to postpone the remainder until they can be presented in full together with a new table of wave-lengths, intensities and other data which are now being collected.

The first regularities in the arc spectrum of columbium were discovered in the sextet system because the strongest lines belong to this system, the separations of the polyfold levels are smaller here than for the quartet-system terms, and also excellent values of the Zeeman effect have been published for some of the lines belonging to this sys-

[4] Spektren der Elemente bei normalem Druck, II, Deuticke, Wien. 1911.
[5] Sitzungsber, d.k. Akad, d. Wiss, Wien. **119** IIa: 559. 1910.
[6] Proc. Roy. Irish Acad. Dublin. **30** A: 42. 1912.

tem. Table 1 contains three multiplets which originate in term combinations of the type DP, DD′ and DF, respectively. Subscripts to the term symbols represent inner quantum numbers. Each one of the permitted combinations gives rise to a spectral line whose estimated intensity, wave-length in air, and corresponding wave number (number of waves per cm vacuo) are shown. The intensities and wave lengths (corrected to the international scale) are from Exner and Haschek, except for the line 4078.34 A which was measured on my plates.

TABLE 1.—MULTIPLETS IN THE ARC SPECTRUM OF COLUMBIUM (SEXTET SYSTEM)

	D_1	154.1	D_2	237.8	D_3	303.4	D_4	355.0	D_5
	4		3		4				
P_2	4116.91		4143.22		4184.44				
	24283.22		24129.07		23891.38				
259.7									
			4		3		10		
P_3			4099.10		4139.43		4192.07		
			24388.76		24151.15		23847.85		
361.6									
					2		8		20
P_4					4078.34		4129.45		4190.93
					24512.87		24209.50		23854.33
	3		20						
D_1	3765.07		3787.11						
	26552.39		26397.90						
161.0									
	20		2		10				
D_2	3742.45		3764.09		3798.14				
	26712.90		26559.29		26321.26				
269.8									
			20		10		20		
D_3			3726.25		3759.58		3802.98		
			26829.00		26591.22		26287.71		
443.8									
					10		20		15
D_4					3697.85		3739.85		3790.15
					27035.06		26731.47		26376.73
547.9									
							8		20
D_5							3664.70		3713.06
							27279.62		26924.35

TABLE 1—*Continued*

	D_1	154.1	D_2	237.8	D_3	303.4	D_4	355.0	D_5
	20		8						
F_1	4168.14		4195.13						
	23984.78		23830.46						
180.0									
	15		20		20				
F_2	4137.15		4163.64		4205.34				
	24164.45		24010.70		23772.62				
231.9									
			20		15		20		
F_3			4123.86		4164.65		4217.98		
			24242.30		24004.87		23701.40		
372.7									
					30		20		15
F_4					4100.99 u		4152.65		4214.75
					24377.52		24074.22		23719.56
430.0									
							30		20
F_5							4079.73 u		4139.74
							24504.52		24149.34
480.4									
									50
F_6									4058.99 u
									24629.76

TABLE 2.—ZEEMAN EFFECT FOR COLUMBIUM LINES

Terms	λ	*Obs.*	*Calc.*
P_2D_1	4116.91	(0.00) 0.00, **1.88**	(0.47) **1.94** 2.88
P_4D_4	4129.45	(0.40) 1.65	(*** **0.44**) *** **1.66** ***
P_3D_2	4143.22	(0.80) 1.85	(0.27, **0.80**) 1.60, **2.13**, 2.66
P_3D_4	4192.07	(0.47) 1.22	(**0.15**, 0.45 *) **0.84**, 1.14****
D_2F_3	4123.86	(0.32, 0.90) **0.47**, 1.02, 1.58	(0.28, 0.83) **0.49**, 1.04, 1.59, 2.15
D_1F_2	4137.15	(1.13) **0.00** 2.20	(1.14) **0.06**, 2.20
D_5F_5	4139.74	(0.45) 1.44	(*** 0.42, **0.55**) **** **1.50** ****
D_4F_4	4152.65	(0.65) 1.45	(** 0.48, **0.67**) *** 1.50 ***
D_2F_2	4163.64	(1.18) 0.66, **1.46**, 2.24	(0.40, **1.20**) 0.67, **1.47**, 2.26
D_3F_3	4164.65	(0.80) 1.50	(* 0.52, **0.86**) *1.14, **1.49**, 1.83*
D_1F_1	4168.14	(1.99) 1.33	(2.00) 1.33
D_2F_1	4195.13	(1.27) 0.84	(1.27) 0.60, 3.13
D_3F_2	4205.34	(0.28, 0.89) 1.26, 2.00, **2.58**	(**0.30**, 0.89) 0.77, 1.36, 1.95, **2.55**

The Zeeman-effect data available for these lines are presented in table 2 together with the patterns calculated according to Landé[7] for the combinations of terms indicated in the first column. The magnetic resolutions are expressed in terms of the separation of a normal triplet as a unit, the parallel components, in parenthesis, being followed by the perpendicular components. The stronger components are distinguished by bold face type, but some of the weaker components of calculated patterns are represented by asterisks. With few exceptions the agreement between observed and calculated results definitely confirms the term combinations assigned to the spectral lines.

The D term with separations 154.1, 237,8, 303.4 and 355.0 wave-numbers, which is common to the multiplets in table 1, is the lowest level in the sextet system, and probably the lowest in the atom, although its exact position relative to other systems has not yet been determined. The most sensitive columbium lines for the purpose of chemical analysis, the *raies ultimes*,[8] occur in the DF combination where they are marked u. This is another instance of such lines arising from a combination of the lowest level in a system with the next higher level having one unit larger azimuthal quantum number, and this may be regarded as a general rule for *raies ultimes*. It seems to be generally true also that such lines permit one to identify the lowest orbit in the atom. A case which appeared to be an exception was mentioned[9] in connection with the arc *raies ultimes* of titanium which were identified as an F^5G^5 group although the low F^5 level is about 6500 wave-numbers higher than the lowest F^3 level. This case has been looked into again and it was found that the lines 3635.47, 3642.68, and 3653.49 A in an F^3G^3 group appear to be equally, if not more sensitive than 4981.73, 4991.06 A, etc., which result from the F^5G^5 combination. If the lines of the triplet system are really the most sensitive for titanium and if the *raies ultimes* always involve the lowest level in the atom it may be of interest to note that according to de Gramont's *raies ultimes* the lowest level in neutral zirconium is represented by an F^5 term, in neutral vanadium by an F^4 term but in columbium by a D^1 term.

[7] Zeitschr. f. Phys. **15**: 189. 1923.
[8] DE GRAMONT. Comptes Rendus **171**: 1106. 1920.
[9] MEGGERS, KIESS and WALTERS. J. O. S. A. & R. S. I. **9**: 355. 1924.

BOTANY.—*New or little known Melastomataceae from Venezuela and Panama. II.*[1] H. PITTIER.

Miconia gatunensis Pittier, n. sp. (Sect. *Tamonea*)

Arbuscula ubique glaberrima, ramis superne plus minusve acute tetragonis inferne teretibus laevibusque; foliis modice petiolatis, subcoriaceis, supra intense subtus laete viridibus, petiolo tereti supra sulcato, laminis ovalibus subobovalibusve tripli- vel subquintuplinerviis, nervis prominentibus, basi rotundatis subacutisve apice abrupte anguste acuminatis, acumine brevi subacuto, marginibus integerrimis, venis transversalibus distantibus utrinque conspicuis, subtus prominulis, parce ramulosis; paniculis terminalibus, basi trichotomis, ad nodos inferiores 4-8-ramulosis, ramulis gracilibus, bis trichotomis; floribus pentameris brevissime pedicellatis, calyce tubuloso-campanulato, limbo obscure sub-5-dentato, persistente, petalis linearioblongis, albis, apice inaequaliter bilobulatis interdum reflexis; staminibus satis inaequalibus, filamentis gracilibus, antheris elongatis, apice attenuatis, uniporosis, basi bilobulatis, lobulis glandulis minutissimis pedicellatis tectis; ovario 3-loculari, glabro, usque ad medium libero, stylo elongato, apice subcapitellato.

Arbuscula 2–3- metralis. Ramuli parce ramulosi, virescentes. Petiolus 1–3 cm. longus; laminae 9–20 cm. longae, 5–7.5 cm. latae, acumine 1–1.5 cm. longo; nervulis transversalibus suberectis, 6–8 mm. distantibus. Paniculae circa 10 cm. longae, laxe pyramidatae. Pedicelli usque ad 0.5 mm. longi. Calyx 4.5–4.7 mm. longus. Petala 4.5–5 mm. longa, 2–2.2 mm. lata. Filamenta 2–6 mm. longa; antherae 5–6 mm. longae. Ovarium 1.5 mm. longum; stylus usque ad 12.5 mm. longus. Bacca ignota.

PANAMA: Humid forest along Río Indio de Gatún, Canal Zone, fl. February 17, 1911, *H. Pittier* 2786 (type).

This species seems to be nearly related to *Miconia subnodosa* Triana, but differs from it in its rather obtuse and terete branchlets, in the shape and dimensions of the leaves, and in the size of the flowers, in which the stamens are manifestly glandulous on the basal lobes.

Miconia septuplinervis Pittier, n. sp. (Sect. *Eumiconia-Aplostachyae*)

Frutex ramulis junioribus cinereis, vix compressis, petiolis pedunculisque dense adpresse hirsutis; foliis breve petiolatis, insigniter 7-plinerviis, petiolo brevi, canaliculato, laminis elliptico-lanceolatis, basi acutatis, apice sensim acuminatis, margine subintegris, ciliatis, supra viridibus parce adpresse hirsutis, nervis supra subtusque dense hirsutis; spicis majusculis, terminalibus, regulariter interruptis; floribus 3–4-glomerulatis, sessilibus, glomerulis oppositis; calyce urceolato, 5-dentato, dense adpresse hirsuto; petalis 5, ovalibus, reflexis, glabris, apice rotundatis; staminibus 10, glabris, filamentis antherae aequantibus, connectivo vix producto. Ovarium 3-loculare; stylus glaber; stigma punctiforme papillosum.

Frutex 2–3 metralis, parce ramosus. Folia in eodem jugo inaequalia; petiolus basi crassus, 6–10 mm. longus; lamina 12–27 cm. longa, 5–11 cm. lata, nervo mediano crassiore, lateralibus margini valde approximatis. Spicae erectae, validae, 12–18 cm. longae, pedunculo anguloso; glomeruli 1.5–2 cm. distantes. Calyx ecostatus, 3.5–4 mm. longus, apice 3.2 mm. latus.

[1] The first of these contributions was published in This JOURNAL **13**: 384–392. 1923.

Petala alba, enervia, 2.5 mm. longa, 1.5 mm. lata. Staminum filamenta gracilia, 2.5–3 mm. longa; antherae lineares e basi leviter attenuatae, 0.6 mm. crassae. Stylus circa 4 mm. longus.

PANAMA: Forests around San Felix, Chiriquí, fl. December 17, 1911, *Pittier* 5175 (type).

This striking species of the subsection *Eumiconia-Aplostachyae* is, so far as I know, the only one in the group with leaves genuinely multiplinerved. In several of the known species, the leaves are said to be trinerved, or almost triplinerved; in a few others they are triplinerved; but in our specimens they are distinctly septuplinerved, the three pairs of opposite nerves showing in light gray on the upper face of the leaf, and being made more conspicuous on the lower face by a neat fringe of gray hairs. Furthermore, these leaves are larger than in any other species of the group, and the spikes are surpassed in length only in *M. longipedunculata* and *M. longispicata*. The flowers, forming regularly distant clusters in which one of them opens at a time, seem to differ also by their superior dimensions.

With the exception of *M. triplinervis* R. & P., reported once from Mexico, *M. septuplinervis* seems to be only species of the *Aplostachyae* found north of the Isthmus of Panama.

Miconia caudiculata Pittier, n. sp. (Sect. *Glossocentrum*)

Arbuscula ramulis acute tetragonis, superne valde compressis, junioribus petiolis pedunculisque dense squamuloso-furfurescentibus; foliis oppositis, membranaceis, breviter petiolatis, nervulo marginali praetermisso 3-plinerviis, petiolo subtus striato supra late canaliculato, laminis oblongo-lanceolatis basi sensim attenuatis et in petiolo decurrentibus, apice angustato in caudiculam tenuissimam squamosulam abrupte contracto, marginibus integris plusminusve revolutis, supra glaberrimis in sicco nigrescentibus, subtus tenuiter stellato-tomentellis pallide viridibus; nervis supra immersis, subtus eleganter prominentibus; paniculis terminalibus, ramosis, folia subaequantibus, ramulis decussatis, subsimplicibus, multifloris; floribus 5-meris, subsessilibus, basi bracteolis minimis subpersistentibus suffultis; calyce globoso subcampanulato, apice vix sinuato, extus squamulis stellato-ciliatis cinereis utrinque tecto; petalis albis, obovatis, oblique retusis, reflexis, glabris; staminibus 10, inaequalibus, saepius reflexis, filamentis glabris, compressis, antheris truncatis late uniporosis connectivo infra loculos modice producto, breviter calcarato, cum filamento geniculato; ovario 3-loculari superne glabro; bacca globoso-depressa, caeruleo-nigrescente, edule.

Arbuscula ad 4 m. alta. Petiolus 1–1.5 cm. longus; laminae 12–20 cm. longae, 3.5–6 cm. latae; caudicula apicalis 4–9 mm. longa. Racemi 15–22 cm. longi, circa 6 cm. diam. Pedicelli 0.1–0.2 mm. longi. Calyx 2.6–2.8 mm. longus, 1.8–2 mm. diam. Petala 2.8–3 mm. longa, 1.7–2.1 mm. lata. Antherae cum connectivo 0.5 mm. producto circa 3 mm. longae. Stylus 6–7 mm. longus. Bacca 6–7 mm. diam., 5 mm. longa.

VENEZUELA: Zulia: Shady banks of the Sta. Ana and Lora rivers, sometimes in close formation, fl. and fr. December 1922, *Pittier* 10955, 10980 (last number the type).

This shrub, which is characteristic of certain shaded strips along the banks of the rivers in the Perijá district of Zulia, belongs to section *Glos-*

socentrum, represented so far in Venezuela only by *Miconia minutiflora* DC. It is likely, however, that besides this latter species and the newly described one, we have also in our territory *M. trichotoma* and *M. longifolia* DC., reported from the island of Trinidad. But *M. minutiflora* and *M. longifolia* belong to the group of species with pentamerous flowers and glabrous leaves, and *M. trichotoma* has tetramerous flowers, so that our *M. caudiculata* is the only Venezuelan representative of the species the leaves of which show a stellate indument on their lower face, species which so far have been known to occur only in Central and South Brazil. The new species should probably be placed close to *M. willdenowii* (Klotzsch) Cogn., from which it is easily distinguished by several characters, without mentioning the striking apical appendage of its leaves, which does not seem to have been noticed in any other species of the genus.

Miconia cuspidatissima Pittier, n. sp. (Sect. *Cremanium*)

Arbuscula ramis teretibus, flexuosis, glabrescentibus, ramulis novellis, petiolis, paniculis, calycibusque pilis plumoso-penicillatis stellulatisve fulvescentibus dense obtectis; foliis modice petiolatis, chartaceis, subconcoloribus; petiolo tereti; laminis ovato-oblongis, 3- vel sub-5-nerviis, margine integerrimis, basi late rotundatis vel interdum leviter emarginatis, apice longe angustissime cuspidatis, supra fere glabris, nervis impressis, subtus praecipue ad nervos venasque prominentes pilis plumoso-penicillatis tectis; paniculis laxis, basi dichotomis; ramulis floribusque trichotomis; pedicellis longis, gracilibus, basi bracteolis subulatis caducis suffultis; calyce late rotundo-campanulato, basi leviter costato, apice duplo 5-dentato, dentibus interioribus scariosis, late acutis, inconspicuis, exterioribus validioribus, conicis; petalis 5, suborbiculatis, vix unguiculatis, apice leviter emarginatis, in sicco luteis; staminibus 10, aequalibus, filamentis glabris, apicem versus attenuatis, antheris filamento duplo brevioribus, biporosis, obcuneatis, connectivo crasso, prominenti, basi bigibboso; ovario calyci adnato, triloculari, stylo glabro apice subclavato vel subcapitellato.

Arbuscula 3–4 m. alta. Petioli 1.5–2.5 cm. longi; laminae (cum cuspide 2–2.5 cm. longa) 10–15 cm. longae, 3.5–6 cm. latae. Panicula circa 10 cm. longa, pedunculo 2.4 cm. suffulta. Pedicelli 2.5 mm. longi. Bracteolae 1.5 mm. longae. Calyx 3 mm. longus latusque, dentibus exterioribus usque ad 0.5 mm. longis. Petala 2.5 mm. longa, 2.3 mm. lata. Stamina glaberrima, filamentis 3.3 mm., antheris 1.6–1.8 mm. longis. Ovarium 1.5 mm. altus; stylus 6.5 mm. longus.

PANAMA: Humid forest on the precipitous slopes between Alto de las Palmas and top of Cerro de la Horqueta, 2100–2268 m., Chiriquí, fl. March 18, 1911, *Pittier* 3224 (type).

This species should be placed either near *Miconia elata* DC., if the leaves are considered as 5-nerved, or if these are 3-nerved, near *M. rigens* Naud., the first a Jamaican, the latter a Colombian plant. The relation, however, seems to be remote, our plant being characterized by the long drip-point of its leaves, by the fulvescent indument formed of long plumose-penicillate hairs on the branchlets, leaves, and rachis of the inflorescence and of stellate hairs on the pedicels and calyx, by the double calyx teeth, etc. This latter character is unusual in Sect. *Cremanium*.

Miconia jahnii Pittier, n. sp. (Sect. *Cremanium*)

Arbuscula ramis tetragonis apice valde compressis ad nodos incrassatis, petiolis pedunculis ramulisque inflorescentiarum dense brununeo-furfurescentibus; foliis approximatis imis longe petiolatis; petiolis angulosis compressis; laminis ovato-lanceolatis basi subrotundatis, leviter attenuatis, apice sensim breviterque acuminatis, margine remote calloso-denticulatis, nervis lateralibus margini approximatis, supra glabris glabrescentibusve, in sicco nigrescentibus, nervis impressis, subtus fulvescente stellato-velutinis, nervis nervulisque prominentibus; inflorescentiis terminalibus paniculatis ovoideo-pyramidatis; floribus sessilibus subsessilibusque, in verticillis densis, approximatis, congestis; calyce urceolato, densiuscule furfuraceo, 5-dentato, dentibus brevibus acutis; petalis late obovatis, albis, patulis, margine irregulariter sinuatis; staminibus 10, glabris, antheris filamento dimidio brevioribus; stylo glabro, apice subclavato.

Arbuscula 2–3 m. alta. Internodii ramulorum foliatorum circa 1.5 cm. longi, defoliatorum 6–8 cm. Petioli 1–2 cm. longi; laminae 7–10 cm. longae, 2.5–4 cm. latae. Paniculae 6–10 cm. longae. Calyx 2–2.5 mm. longus, 2.4 mm. latus, dentibus circa 0.6 mm. longis. Petala 2–2.2 mm. longa, 1.7–2 mm. lata. Staminorum filamenta 2–2.5 mm. longa; antherae cuneatae, truncatae, biporosae, 1.7–1.9 mm. longae. Stylus 3–3.5 mm. longus.

VENEZUELA: Páramo Quirorá, 3000 m., Andes of Mérida, fl. January 24, 1922, *Jahn* 876 (type).

This species is nearly related to *Miconia granulosa* Naud., reported from the Eastern and Central Andes of Colombia and from Bolivia. It differs mainly in its smaller leaves, shorter panicles, and larger flowers. It grows on the margin of the high andine páramos.

Conostegia excelsa Pittier, n. sp.

Arbor pro genere excelsa, trunco erecto, coma elongata, sparsa, ramulis haud compressis, petiolis, laminis subtus atque inflorescentiis plus minusve dense furfuraceis; foliis longe petiolatis, 5-nerviis, coriaceis, integerrimis, petiolo evanescente furfuraceo, anguloso, laminis ovatis subobovatisve, basi obtuse rotundatis, apice late obtusis supra nervies interdum furfuraceis exceptis glaberrimis, nervis venisque transversalibus impressis, subtus nervis dorso interdum denudatis exceptis dense canescente furfuraceis, nervis venis venulisque prominentibus; paniculis brevibus, latis; floribus graciliter pedicellatis invisis; pedicellis leviter furfuraceis; bacca 5-loculari, basi stellato-furfurascente excepta glaberrima, semiglobosa; seminibus clavatis, apice truncatis, laevibus.

Arbor 20–25 m. alta. Petioli 2.5–6 cm. longi; laminae 7.5–17 cm. longae, 6–10.5 cm. latae. Pedicelli 6–8 mm. longi; bacca 0.5 cm. longa, apice 8 mm. diam. Semina 1–1.2 mm. longa, apice 0.4 mm. lata.

PANAMA: Humid forest around Los Siguas Camp, southern slope of Cerro de la Horqueta, at about 1700 m., Chiriquí, fr. March 18, 1911, *Pittier* 3196 (type).

In the absence of the flowers, it is difficult to establish the relationship of this species. It may be allied to *C. macracantha* Triana, but differs in the large size of the tree, in the 5-nerved leaves and in the apparently 5-merous flowers.

Topobea micrantha Pittier, n. sp.

Arbuscula marginis foliorum ciliatis exceptis glaberrima, ramis gracilibus flexuosisque teretibus, ramulis apice tetragonis; foliis parvis, petiolatis, 3–5-nerviis in eodem jugo inaequalibus; petiolo longo, gracili, canaliculato; laminis late ovalibus suborbiculatisve basi acutissimis, apice abrupte breve acuminatis, margine leviter revolutis remote denticulatis ciliatisque, supra laete viridibus nervo medio prominulo, lateralibus subimpressis, subtus glaucescentibus nervis prominulis, supra subtusque densiuscule rufo-punctulatis; inflorescentiis axillaribus, brevibus, pedunculatis, trichotomis, copiose bracteolatis; pedunculo brevi, basi ebracteato; bracteolis oppositis, decussatis, spathulato-oblongis, basi longe attenuatis, apice obtusis, margine crenato-denticulatis, interdum ciliatis, trinerviis, plus minusve punctulatis, quam flores longioribus; floribus parvis, 5-meris, pedicellatis; pedicellis brevibus; calyce tubuloso-campanulato, leviter 10-costato, limbo 5-lobulato, lobulis late rotundatis, scariosis, extus dentibus validis subaequilongis productis; petalis 5, orbiculatis, albo-roseis, vix unguiculatis, apice levissime emarginatis; staminibus 10; ovario 4-loculari; bacca sicca, moriformi, calycis lobulis persistentibus coronata; seminibus paucis, obovato-cuneatis, punctulatis.

Arbuscula 1–3 m. alta. Petiolus 0.8–1.8 cm. longus; laminae 3–5 cm. longae, 1.5–2.8 cm. latae. Inflorescentiae 1–1.5 cm. longae; pedunculus 0.4–0.5 cm. longus. Pedicelli 0.5–1.5 mm. longi. Bracteolae 5–7 mm. longae, 1.5–1.8 mm. latae. Calyx 2.5 mm. longus (tubus 1.7 mm., lobulis 0.8 mm.), apice tubi 1.8 mm. latus. Petala 2.5 mm. longa lataque; et caeterae ignotae.

PANAMA: Humid forests on the precipitous western slope of Cerro de la Horqueta, 2100–2268 m., Chiriquí, fl. and fr. March 18, 1911, *Pittier* 3276 (type).

It is not without hesitation that this remarkable plant is placed in genus *Topobea*. It agrees with this, it is true, in the general characters of the flower, fruit, and seeds, but the flowers and leaves are very small as compared with those of the other species of the genus, and the imperfect stamens at my disposal also seem to be different in their structure. In the bud, however, they are disposed in the same way as in *Blakea* and *Topobea*, the anthers being bent down inward so that their tips occupy the hollow at the apex of the ovary, around the style. The bracts, longer than the flowers, are not imbricate, but somewhat distant and decussate. Other striking characters are the ciliate leaves (noted also in *T. ciliata* from Ecuador), and the numerous brown dots on the leaves, which, on closer observation, are found to be formed by dense groups of diminute squamose hairs. Identical dots are seen on the leaves of *T. punctulata* and *T. latifolia*, from Colombia, as well as on those of *T. superba* and *T. regeliana*, both of which grow within the limits of Panama, but are not at all closely related to our plant.

BOTANY.—*Five new plants from Venezuela.* S. F. BLAKE, Bureau of Plant Industry.

Four of the new species described in this paper are from high altitudes in the Andes of the States of Trujillo and Mérida, Venezuela. One is a striking *Draba*, with stout stem, fleshy leaves, and large yellow flowers; one is a species of *Aragoa*, a genus of shrubs allied to *Veronica*, and previously known only from Colombia; one is an alpine *Erigeron*, allied to *E. nevadensis* Wedd.; and the fourth is a species of *Desmanthodium*, a small genus of the *Heliantheae-Millerinae*, hitherto found only in Mexico and Guatemala. The fifth plant belongs to *Riencourtia*, and is the second new species of that genus collected in Venezuela by Mr. Henry Pittier.

Draba bellardii Blake, sp. nov. Caudex thick, with few short branches; stem low, thick, stellate-pubescent; basal leaves tufted, fleshy, yellowish green, oblong, serrate above, ciliate; stem leaves similar but shorter and broader; inflorescence dense; pedicels 1 cm. long or less; petals yellow, 7.5–10 mm. long; ovary glabrous, the ovules about 20 in each cell; style and stigma 2 mm. long.

Herbaceous perennial, about 14 cm. high; caudex thick, 4-branched, the branches short, erect, densely clothed toward apex with the imbricated corky bases of fallen leaves, one bearing a flowering stem, the others dense tufts of leaves; basal leaves tufted, fleshy, yellowish-green, sessile, narrowly oblong or oblanceolate-oblong, 4 to 5 cm. long, about 1.2 cm. wide, acute, serrate above the middle (teeth about 4 pairs, acute or acutish), hirsute-ciliate below the middle and denticulate-hirsute-ciliate above, the broad yellowish-white costa antrorse-hirsutulous with simple hairs on upper surface of leaf, glabrous beneath like the whole under surface; flowering stem leafy, stout (nearly 1 cm. thick), angled and striate, yellowish green, evenly but not densely stellate-pubescent with spreading, 2- or 3-branched hairs; stem leaves similar to the basal but rather shorter and broader, with slightly clasping base, the upper ones (subtending the lower branches of the inflorescence) ovate, about 2.5 cm. long, 1.5 cm. wide, pubescent like the basal leaves, about 7-toothed on each side above the entire base; inflorescence about 7 cm. long, dense, leafy-bracted, short-branched below, the flowers congested; pedicels in anthesis 1 cm. long or less, stout, pubescent like the stem; sepals oblong or obovate-oblong, 7 to 8 mm. long, 3.5 mm. wide, rounded, yellowish green, sparsely hirsute along midline with simple or bifurcate ascending hairs; petals yellow, equal, 7.5 to 10 mm. long, glabrous, the claw 2.5 to 4.5 mm. long, about 1.2 mm. wide, the blade suborbicular, subtruncate, 5 to 5.5 mm. long, 5.5 to 6.5 mm. wide, about 8-nerved; stamens 6, free, equal, the stout subulate filaments 5.5 to 6 mm. long; ovary ellipsoid, glabrous, 5 mm. long, the ovules pendulous on slender funicles, in two rows of about 10 each in each cell; style and stigma 2 mm. long, the style cylindric-conic, the stigma slightly bilobed.

VENEZUELA: At the perpetual snow line, Sierra de Mucubajá, Andes of Mérida, altitude 4,880 meters, 1922, *E. P. de Bellard* 14 (type no. 1,185,120, U. S. Nat. Herb.).

Remarkable for its very stout leafy stem and large yellow flowers. The species evidently belongs in the section *Volcanicae* of Gilg, and is nearest the Colombian *Draba pachythyrsa* Triana & Planch., which is described as having lanceolate few-dentate leaves, contracted into a short broad petiole, violascent calyx, a very short style, and about 6-seeded capsule cells.

Aragoa lucidula Blake, sp. nov. Branches pilose-lanate; leaves oblong, 2–2.8 mm. long, obtuse, appressed, not keeled, shining, pubescent on back and margin; flowers sessile, small; calyx pubescent; corolla pilose at base of tube.

Shrub; branches and branchlets numerous, mostly opposite or in 3's, the branchlets 1.5–2 mm. thick (including the leaves), terete, cinereously pilose-lanate, densely covered by the appressed, crowded, long-persistent, many-ranked leaves; leaves of main stem linear-oblong, 2.8 mm. long, about 0.5 mm. wide, obtuse, concave inside, sparsely pilosulous dorsally, those of branches and branchlets oblong, 2–2.6 mm. long, 0.8 mm. wide, obtuse, thick, concave and glabrous inside, rounded and loosely pilose on back, ciliate especially toward apex, dark green and shining, with narrow pale margin; flowers few toward apex of branches, sessile; calyx 5-parted, 2–2.8 mm. long, the segments imbricated, oval, rounded, 1.5 mm. wide, subcoriaceous, with green center and subequal subscarious margins, pilose on the green portion of back, especially toward apex, and ciliate; corolla campanulate-rotate, 4-lobed about to middle, 7 mm. wide, long-pilose in a ring at base inside, otherwise glabrous, the campanulate tube 2 mm. long, the obovate-oblong rounded entire lobes 3 mm. long; stamens 4, the filaments flattish-subulate, 3 mm. long, pilose about to middle, adherent to tube throughout its length, the anthers reniform, confluently 1-celled; disk annular, thick; ovary globose-ovoid, glabrous, shorter than style, 2-celled, several-ovuled; capsule ovoid, glabrous, 2 mm. long, 4-valved, the valves thick, the septum free; seeds (immature?) obscurely winged.

VENEZUELA: Sierra Nevada de Santo Domingo, Mérida, altitude 3600 meters, 12 Sept. 1922, *A. Jahn* 1091 (type no. 1,186,693, U. S. Nat. Herb.).

Aragoa lucidula is the first species of the genus to be found in Venezuela. From the three species of the genus previously known, all of which are Colombian, it is distinguished by its small flowers and dorsally pubescent leaves. The vernacular names given by Dr. Jahn are "romero negro" and "chicote," the former signifying "black rosemary," the latter ("end of a rope," Velázquez Dictionary) presumably referring to the ropelike appearance of the branches. The name "romero de páramo" is given on a sheet of *A. cupressina* H. B. K. in the National Herbarium, collected by Triana near Bogotá.

Erigeron blepharophyllus Blake, sp. nov. Perennial, with short and thick rhizome; leaves all in a basal tuft, narrowly cuneate or oblanceolate, about 5 cm. long, narrowed to the sessile base, denticulate toward apex, densely pilose and stipitate-glandular; stem scapiform, 1-headed; involucre subequal, glandular-pilose; rays numerous, about half longer than the involucre; achenes hispid.

Rhizome erectish, about 1.5 cm. long, simple; basal leaves 12 or more, 4.5–6 cm. long, 4–8 mm. wide, erect or in age reflexed, acute or obtuse and

somewhat callous-thickened at apex, gradually narrowed to base, about 4-denticulate on each side toward apex with small blunt callous teeth, 1-nerved or with a pair of lateral nerves well above the base (the nerves all impressed), densely pilose with many-celled acuminate hairs on both sides and on margin and also stipitate-glandular, thick-herbaceous (perhaps fleshy in life), subscarious and glabrous within toward the base, this about 5-nerved; stems one or two, erect, 12–22 cm. high, densely pubescent with dark several-celled gland-tipped hairs and sparsely pilose, bearing 2–4 linear bracts, these 3–13 mm. long, 0.5–2 mm. wide, pubescent like the basal leaves; head 2 cm. wide; disk 7–8 mm. high, 12 mm. thick; involucre about 2-seriate, 8–9 mm. high, the phyllaries linear (1 mm. wide), acuminate, erect, the outer dull green or purplish, stipitate-glandular and pilose, with very narrow or obsolete scarious margin, the inner whitish, indurate, with narrow scarious margin, 1-vittate, ciliate chiefly toward apex, otherwise nearly or quite glabrous; rays about 40, sub-2-seriate, whitish (when dried), considerably exceeding the involucre, the tube 2 mm. long, erect-pilose with several-celled hairs, the lamina linear-elliptic, bidenticulate, 4-nerved, 6 mm. long, 1.7 mm. wide; disk corollas apparently whitish, erect-pilose with several-celled hairs at base of throat and sparsely so on teeth, 4 or 5-toothed, 4.3 mm. long (tube 1.8 mm., throat funnelform, 1.3 mm., teeth ovate, obtuse or acute, 1.2 mm. long); achenes (immature) of ray and disk slender, hispid, several-nerved, 2.5 mm. long; pappus of 25–30 hispidulous rufid bristles 4 mm. long, a few of the outer only about half as long; anthers sagittate at base; style branches with lanceolate, acute, finely papillose-hispidulous appendages.

VENEZUELA: Páramo del Jabón, Trujillo, altitude 3300 m., 2 Oct. 1910, *Alfredo Jahn* 46 (type no. 602241, U. S. Nat. Herb.); Páramo de Aricagua, Mérida, altitude 3300 meters, 31 March 1922, *Jahn* 1035.

Allied to *Erigeron nevadensis* Wedd., which is similar in appearance but is not glandular, and has merely ciliolate leaves with glabrous faces.

Desmanthodium blepharopodum Blake, sp. nov. Stem essentially glabrous; leaves ovate, denticulate, subcoriaceous, practically glabrous, on rather short densely ciliate petioles; heads medium-sized for the genus, 6–10-flowered.

Stem herbaceous above, rather stout, subterete, hirsutulous chiefly in 2 lines with mostly appressed, several-celled hairs, quickly glabrate; leaves opposite; petioles unmargined, connate at base, densely ciliate with several-celled sordid hairs, 3–13 mm. long; blades ovate, 7–17 cm. long, 3.5–7 cm. wide, acuminate, at base cuneate, remotely denticulate (teeth about 0.5 mm. high, 5–8 mm. apart), subcoriaceous, hirsute-ciliate when young, above deep dull green, very sparsely hirsutulous, beneath slightly lighter green, very sparsely hirsutulous along some of the veins or essentially glabrous, quintuplinerved well above the base, the nerves impressed above, with the secondaries loosely prominulous-reticulate beneath; panicle trichotomous, flattish-topped, 14 cm. wide, its branches sordid-hirsutulous in lines with spreading or ascending hairs, the branchlets strongly flattened, hirsutulous on the upper side, the bracts (except the lowest pair) 1 cm. long or less, ovate, coriaceous; heads sessile, about 5 mm. high, 3 mm. thick, 6–10-flowered, crowded at tips of branchlets in glomerules about 1 cm. thick; outer phyllaries 4, the outermost one suborbicular, about 10-nerved, the others smaller, oblong or obovate, all whitish, subscarious, rounded, glabrous;

♀ flowers 3, inclosed in bottle-shaped, strongly obcompressed, obliquely truncate, few-nerved, glabrous, whitish phyllaries 3.5–4.5 mm. long and 2 mm. wide, their corollas whitish, tubular-funnelform, glabrous, 1.5 mm. long, the limb irregularly about 6-toothed; disk flowers (sterile) 3–7, their corollas whitish, 2–3 mm. long, hirsute above, with subcylindric tube, short campanulate throat, and 5 erect teeth longer than the tube and throat; receptacular pales none; achene obcompressed-trigonous, obovoid, glabrous, blackish, 2.8 mm. long, 1 mm. wide, crowned with a fleshy ring; sterile ovaries oblong to linear, 1–3 mm. long, hirsutulous with 1-celled hairs.

VENEZUELA: Between La Puerta and Timotes, States of Trujillo and Mérida, altitude 2000 meters, 16 Sept. 1922, *Alfredo Jahn* 1143 (type no. 1,186,743, U. S. Nat. Herb.).

Nearest *Desmanthodium guatemalense* Hemsl., which has glaucescent branches and thin-membranous, more or less rhombic-ovate, subsessile leaves which are not ciliate at the base. No species of the genus has hitherto been known outside of Mexico and Guatemala, the Colombian plant described as *Desmanthodium trianae* Hieron. being really a typical *Clibadium* (*C. trianae* (Hieron.) Blake, Contr. Gray Herb. n. ser. **52**: 6. 1917).

Riencourtia pittieri Blake, sp. nov. Stem strigose; leaves mostly ovate or elliptic-ovate, 3.5–4.8 cm. long, 1.5–1.7 cm. wide, hirsute and hispidulous; heads in few glomerules, 9-flowered.

Erect herb, about 55 cm. high, the base not seen; stem slender, with short erectish branches, evenly but not densely strigose with tuberculate-based hairs; internodes 6 to 12.5 cm. long, much surpassing the leaves; leaves opposite, those of the main stem about 7 pairs; petioles hispid-strigose, 2 to 3 mm. long; blades of the lowest leaves oval-ovate, about 2 cm. long, 1 cm. wide, obtuse, those of the middle and upper ovate or elliptic-ovate, 3.5 to 4.8 cm. long, 1.5 to 1.7 cm. wide, acute or acutish, rounded at base, serrate (teeth about 9 pairs, depressed-triangular, mucronulate), above deep dull green, hispid and hispidulous with tuberculate-based mostly incurved hairs, beneath lighter green, hispid-hirsute and hispidulous along all the veins and veinlets with spreading or divergent hairs, triplinerved from near the base (the lateral nerves with a basal branch) and prominulous-reticulate beneath, impressed-veined above; peduncles solitary at tips of branches, ternate at apex of stem, 4 to 5.5 cm. long, strigose; glomerules about 1 cm. wide and high, subtended by a pair of reflexed lanceolate bracts about 12 mm. long; heads (excluding corollas) 5 mm. high, 3 mm. wide, compressed, 9-flowered; phyllaries 4, dry, whitish, hispid above, mucronulate, the two outer folded, 4.2 mm. long, the two inner flattish, 5 mm. long; ♀ flower 1, the corolla not seen; disk flowers (sterile) 8, their corollas yellowish-white, 3 mm. long (tube slender, 1 mm., throat campanulate, 1 mm., teeth 5, ovate, 1 mm. long), the teeth hispid-hirsute with spreading hairs above on back, inside densely barbatulate and with a tuft of longer hairs at apex; achene obovoid, plump, pilose, margined, 3.2 mm. long, 2.2 mm. wide; sterile ovaries linear, pilose, 4 mm. long or less.

VENEZUELA: In savannas, Upper Cotiza, near Caracas, altitude 1250 meters, 18 Sept. 1921, *Pittier* 9824 (type no. 1,122,830, U. S. Nat. Herb.).

This plant is nearest the Brazilian *Riencourtia latifolia* Gardn., with which it agrees in most characters. No material of *R. latifolia* has been examined, but Dr. A. B. Rendle and Mr. John Hutchinson, who have examined the

material of the type collection (*Gardner* 3280) in the British Museum and the Kew Herbarium, inform me that the stem-pubescence is wide-spreading in that species, while it is closely appressed in *R. pittieri*. *Riencourtia pittieri* is the second species of the genus known from Venezuela, the other being *R. ovata* Blake, recently described from specimens collected by Mr. Pittier in savannas near Valencia, State of Carabobo.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

668TH MEETING

The 668th meeting was held in the lecture hall of the Cosmos Club, May 10, 1924, at 8 p.m. with Vice-President GOLDMAN in the chair and 36 persons present. New members elected: IRVING L. TOWERS, MURRAY T. DONOHO.

Under *Short Notes*, C. P. HARTLEY demonstrated that length of day was the factor limiting the amount of growth of stalk in the smaller varieties of corn. Specimens exhibited showed conclusively that in the same variety the stalk of an April planting was decidedly shorter than a stalk planted in June, though the two had grown in adjacent rows only four feet apart. In larger varieties conditions were equalized because of the longer growth period.

I. N. HOFFMAN exhibited and commented upon several of the largest known species of Coleoptera, belonging to the family *Lucanidae*.

In continuation of discussion of Mr. Hartley's note A. A. DOOLITTLE reported that corn planted for classroom study in October made a very short stalk. Mr HARTLEY considered this as probably due to the shortness of winter days.

E. A. GOLDMAN called attention to a belief prevalent in many places in the Tropics that timber cut in certain phases of the moon produces lumber more resistant to rot and insect infestation.

J. M. ALDRICH reported that one of the beetles exhibited by Mr. HOFFMAN, *Dynastes tityus*, frequently may be identified by its peculiar odor, even when the insect iself is not seen. He also stated that it was expected that Professor MARIO BEZZI, an Italian entomologist and a student of Diptera of high reputation, would come to this country to examine our National Park System for his government, and in addition under a grant from the National Research Council, to study insect life at high altitudes.

E. D. BALL: *Migratory habits of insects in arid regions* (Illustrated by slides). Migration is an adaptation that enables species to occupy regions which would otherwise be uninhabitable. Migratory habits in birds are well recognized phenomena. There are also many curious and interesting cases in insects. The milkweed butterfly each fall gathers in great swarms and flies southward from the Great Lakes and Manitoba to the Gulf regions. The black witch, a large Noctuid, reverses this process and flys northward from Cuba, oftentimes reaching the northern states, occasionally as far as Saskatchewan. Many other moths fly northward annually from southern regions. The migratory locusts of the Bible and similar species in South America, South Africa, and eastern Russia, in the course of their migrations cause great damage. In former times the buffalo came down in winter out of the mountain regions to sheltered spots on the plains. Lady beetles

reverse this process and fly to the exposed tops of mountains, where they gather in large swarms for hibernating purposes. Beet leafhoppers fly from the deserts to the beet fields in the irrigated valleys of the west. In the examples mentioned the migratory habit affects all individuals of the species alike and they all migrate at a stated time.

There is another type of migration in which only certain specially modified individuals take part. Many modifications of this kind are found in the arid regions of the western country. Most of the leafhoppers that feed on the short grasses have abbreviated wings, an adaptation which enables them to move about freely in these tangles. The areas they inhabit are subject to periodic droughts in which animal life, including even the insects, may be destroyed. These insects have a special migratory form with slender body and long wings that is capable of flying long distances. These migratory forms always appear very early in the season from the first nymphs that mature. Within a few days of emergence they fly away to other regions and thus distribute the species, leaving only the normal short-winged forms in the original location.

The Rocky Mountain Locust which was so destructive in the western regions from 1872 to 1876, was considered to be a distinct migratory species of grasshopper (*Melanoplus spretus*). Studies made during the recent outbreak have shown that this grasshopper is not a true species but only a specially modified long-winged migratory form of the common injurious grasshopper of the northern part of the United States (*Melanoplus atlantis*). Production of excessive numbers of the migratory form is probably correlated with periodic droughts. It is probable that migratory forms are present in many species in which they have not as yet been recognized. (*Author's abstract.*)

Discussion by J. M. ALDRICH, C. W. STILES, M. B. WAITE, E. A. GOLDMAN, and A. S. HITCHCOCK.

A. WETMORE, *Secretary, pro tem.*

SCIENTIFIC NOTES AND NEWS

Professor W. L. CORBIN, formerly of Boston University, has been appointed Librarian of the Smithsonian Institution. He succeeds PAUL BROCKETT who is at present Assistant Secretary of the National Academy of Sciences.

MRS. AGNES CHASE, assistant agrostologist of the Department of Agriculture, sailed for Rio de Janeiro October 18. She will remain about six months in Brazil studying and collecting grasses.

NEIL HOTCHKISS, a graduate of Syracuse University, has been appointed assistant in agrostology (junior botanist), Bureau of Plant Industry.

Dr. W. A. Orton has resigned as Pathologist in charge of the office of cotton, truck, and forage crop disease investigations in the Bureau of Plant Industry, to become scientific director and general manager of the Tropical Plant Research Foundation.

Dr. Orton entered the service of the Department of Agriculture in 1899, and has been prominently associated with its activities for slightly more than twenty-five years. In recognition of his long service an informal farewell dinner was given at the City Club, November 13, by his associates.

The Pick and Hammer Club held its first autumn meeting at the Geological Survey on October 25. Program: TAYLOR THOM, *The International Petroleum Congress at Tulsa;* FRANK HESS, *Chasing rare minerals;* DAVID WHITE, *The British Association meeting.*

NEIL M. JUDD, Curator of American Archeology, United States National Museum, returned to Washington September 30th. Mr. Judd has been engaged for four months in continuation of the National Geographic Society's explorations at Pueblo Bonito, Chaco Canyon National Monument, New Mexico. The past season's investigations constituted the fourth year of field work of the five year project previously noted in the Journal. Besides a noteworthy collection additional data bearing on prehistoric peoples of the Southwest were gathered. It is felt that the 1924 explorations have proven the most profitable of the series.

Two courses of lectures are being given at the National Museum at 4.30 p.m. Fridays and Mondays by DR. ALEŠ HRDLIČKA. The first, which commenced on October 24 and is given on Fridays, is entitled *Man's origin,* and includes: a. *Evolution in nature, its causes and objects;* b. *What is "man?" His relation to other living beings;* c. *Man's origin; the material evidence bearing on the subject;* d. *The why, where, when, and how of man's ascent;* e. *Man's spread and differentiation;* f. *The racial composition of existing nations;* g. *Man's present and future.* The second course, given on Mondays, entitled *Man's physical and physiological characteristics,* includes: a. *The life cycle of man; the developmental stage, growth, the adult stage, senility, death;* b. *The adult body, pigmentation, skin, eyes, and hair; stature, weight; the head, the face, rest of the body;* c. *The brain; organs of sense;* d. *The functions of the body;* e. *Mentality.*

NED HOLLISTER, Superintendent of the National Zoological Park since 1916, and one of the foremost mammologists of the world, died November 3, following an operation.

Mr. Hollister was born at Delavan, Wisconsin, November 26, 1876, where he received his education and began the study of zoology. From 1902 to 1909 he conducted zoological field work for the Biological Survey in the west. In 1910 he was appointed Assistant Curator of Mammals in the U. S. National Museum; this position he held until 1916 when he became Superintendent of the Zoological Park. In 1912 he represented the Smithsonian Institution on the Smithsonian-Harvard Expedition to the Altai Mountains, Siberia.

Mr. Hollister was the author of a number of important works on zoological subjects, including *The birds of Wisconsin* (1903), *Mammals of the Philippine Islands* (1911), *Mammals of the Alpine Club Expedition to Mount Robson* (1913), and *East African mammals in the U. S. National Museum* (1918, 1919, 1923). The last, probably Mr. Hollister's chief contribution to science, is a complete technical account of the East African collections made by Theodore Roosevelt, Paul Rainey, and others.

During Mr. Hollister's term of office as Superintendent, the National Zoological Park has shown steady growth and development. Many improvements to the grounds and animal quarters were carried out, and he made every effort to provide for the enjoyment and convenience of the public.

Mr. Hollister was a member of the ACADEMY and served as Associate Editor of this JOURNAL from 1919 to 1923, representing the Biological Society.

ARCHIVE
http://Archivebeta.Sakhrit.com